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Governance experiments in climate action: empirical findings from the 28 European Union countries

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ABSTRACT

Climate targets call for novel policy measures to facilitate widespread adoption of low-carbon solutions and innovations. The literature on socio-technical systems argues that experimentation has a prominent role in enabling sustainability transition. Experiments represent ways of testing new ideas and methods across a wide range of policy fields. Governance experiments in particular can support accelerated diffusion of new solutions, because they integrate policy with innovations. Here, types of success factors in the implementation of governance experiments to mitigate climate change are examined. Statistical analysis of sustainability innovations in the 28 European Union countries indicates that the types of success factors in governance experiments differ from those of product and social experiments. Governance experimentation is more positioned within socio-technical regimes than in strategic niches. These results suggest that governance experiments may indeed provide new transition opportunities towards low-carbon societies.

KEYWORDS Governance experiment; climate action; success factor; multi-level perspective; socio-technical regime; sustainability transition

Introduction

Novel policy measures facilitate transition to sustainable, low-carbon societies. Yet policies on climate action challenge conventional rationales for government interventions as well as the forms of their implementation, which typically target improvements in existing systems rather than new solutions (see, Baldwin and Cave 1999, Bäckstrand *et al.* 2017). Many of the current climate challenges not only prompt innovations in governance but may rely on them. Furthermore, ambitious climate change agreements call for novel measures at international, national and local levels, and require quickly launched and widespread adoption of low-carbon solutions. Novel targets and the absence of established regulatory instruments call for innovations in governance. Governance innovations may support and accelerate

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the diffusion of new solutions because they enable efficient use of existing clean technology and learning from experimenting (see, Brown and Vergragt 2008, Evans 2011, Bos and Brown 2012). Cities, for instance, are experimenting with different approaches in city planning and implementation of climate actions (Hodson and Marvin 2010, Anguelovski and Carmin 2011, Evans 2011).

We analyse governance experiments on climate action against the framework of the multi-level perspective (MLP) on socio-technical systems that scholars often use to study sustainability transitions (e.g. Geels 2002, 2005, Smith *et al.* 2005, Berkhout *et al.* 2010, Geels *et al.* 2016). In essence, governance experiments represent ways of trying out new ideas and methods in settings in which uncertainty of impacts needs to be accepted (Castán Broto and Bulkeley 2013; see also, Kemp *et al.* 1998, Berkhout *et al.* 2010). Governance experiments, further, have more wide-ranging societal targets than small-scale technology-based experiments (Hoogma *et al.* 2004). This novelty-seeking yet inclusive character forms the rationale for experimentation and subsequently calls for innovations in governance. Here, we examine governance experiments in climate action in an empirical database on sustainable innovation.

We first frame our study by reviewing the role of governance experimentation in sustainability transition towards low-carbon societies. We examine what constitutes an experiment in governance and why experimentation can be considered an interesting way to further governance. We also introduce the applied typology of innovation, which follows the *Oslo Manual* (OECD 2005), and discuss different types of success factors for innovations that we operationalise when presenting data on climate action experiments from the 28 European Union (EU-28) countries in an open database. We observe empirical experiments in climate action and review the types of success factors against the kinds of innovations to explore how governance experiments differ from other kinds of experiments.

Our special focus is on investigating categories of success factors, which are understood to be prerequisites for the success of the experiment in terms of its implementability and targeted realisation. We also discuss our research as an exploratory way to provide an indication of how governance innovation may compare with other kinds of innovation in the area of climate action. In concluding, we evaluate how the results contribute to the emerging research field of experiments in climate change (Bos and Brown 2012, Kivimaa *et al.* 2017).

Research frame of the study

The MLP is an analytical and heuristic framework introduced by Rip and Kemp (1998), further developed by Geels (2002, 2005) and used, for

example, by Berkhout *et al.* (2010), Smith *et al.* (2005) and Upham *et al.* (2014) to examine socio-technological transitions. The MLP is a hierarchically portrayed framework with the *socio-technical regime* in the middle (i.e. meso) level. The literature on MLP defines a regime to consist of existing rules, regulations, institutions, markets, culture and technology. Governance thus forms an integral part of established socio-technical regimes. Innovations try to break upwards from *niches* (micro level), that are so-called protected spaces within which innovations can be nurtured and evolve; slowly evolving *landscape* developments (macro level), such as climate change, put downward pressures on the socio-technical regime (Geels 2002, Scrase and Smith 2009). Both initiate changes in the socio-technical regime.

While governance has the potential to achieve major societal impacts, its practices are also cumbersome to change. Experimentation and innovation may provide new options for governance, while still adhering to publicly accepted policy targets, and thereby facilitate desired transition as means for socio-technical regimes to renew themselves. Indeed, also Geels *et al.* (2016) suggest scholars should address multiple niche and regime innovations jointly. The concept of regime used in the MLP resembles those used in other contexts such as in international politics and economy to describe arrangements and commonalities (Krasner 1982, Hall and Soskice 2001, Holtz *et al.* 2008, Repo and Timonen 2017), but it is applied in a socio-technical setting.

We argue that governance experimentation takes place mainly within regimes as it depends on co-operation between, or at least the compliance of, regime actors such as governmental agencies and established companies with powerful vested interests. Rip (2006) and Smith *et al.* (2010) see regimes themselves as a form of governance as they structure and order the interaction of material and social processes. Moreover, regime actors can mobilise sufficient resources for the realisation of the experiment. Examining governance experiments provides an opportunity to review the receptiveness of socio-technical regimes to further transition as governance experimentation may provide a means to overcome problems in developing policy innovation and difficulties in establishing strong political programmes for sustainability transition (see, Scrase and Smith 2009, Upham *et al.* 2014). The notion that governance itself takes place at various levels and in overlapping and interconnected horizontal spheres supports this (Hooghe and Marks 2001, Bulkeley and Betsill 2013).

Scholars have typically addressed changes, or the lack of them, in socio-technical regimes conceptually or by examining a limited number of cases (Scrase and Smith 2009, Bulkeley and Betsill 2013, Upham *et al.* 2014). We complement these studies empirically by analysing a large number of cases. We examine 141 climate action experiments from the EU-28, which are

extracted from a database developed by a European research project examining sustainable innovation, CASI. The database provides a wide variety of cases, ranging from local mobilisation initiatives to internationally adopted business concepts and from large-scale industries such as the energy sector to micro-level solutions such as household services. We use the terms experiment and innovation interchangeably as governance experiments consist of, and also partly represent, innovations. Once the experiments end by termination or by becoming a regular feature of governance, interchangeability of these terms would also end, but that is beyond the scope of this study, which focuses on the ongoing stage of governance experiments.

We compare governance innovations against other kinds of innovations (organisational, product, service, social and system) depicted in the database in terms of success factors in order to examine differences across kinds of innovations and to draw lessons for the future development of governance experimentation in climate action. This comparative analysis positions governance innovation (such as the case on 'Sustainable Energy Landscapes', which focuses on recognition of the possibilities for the production of renewable energy in rural areas) in relation to other kinds of innovation (such as the product innovation 'Domoki', a new home automation device) in the area of climate action. The database does not provide assessment of the successes of the innovations, but for our analysis this is not relevant as we are examining issues that are critical for the implementation of innovations and draw conclusions on whether the factors differ across the kinds of innovations. The categories of success factors in the database can be economic, environmental, political, social or technological. These are described in greater detail when we present the database. Next, we look at governance experimentation and its role in low-carbon transition.

Governance experimentation in low-carbon transition

While there is no single solution to the problem of climate change, supporting transition towards low-carbon societies through governance and policy activities is a reasoned way forward (Bulkeley and Betsill 2005, Conklin 2006, Kemp *et al.* 2007, Partzsch 2017). In fact, it is difficult to see climate change being efficiently tackled without considering governance interventions and innovations in governance. We share Bulkeley and Castán Broto's (2013) argument that governance interventions may meaningfully be studied in terms of experiments, because these acknowledge the tentative nature of governance interventions and shift attention to the process of developing new practices. Experimentation is then a way to learn about the desirability of new solutions while building momentum to further develop them (Kemp *et al.* 1998). In this respect, experiments are a method for obtaining and assessing new knowledge, practices and network

in climate governance (Seyfang and Smith 2007, Brown and Vergragt 2008, Hoffmann 2011, Bulkeley *et al.* 2012). Experiments are a potential means through which policies diffuse and introduce socio-technical transformations (Matschoss and Heiskanen 2017). Experimentation may also prompt transition by testing different kinds of technologies and solutions (Hodson and Marvin 2010, Evans 2011).

Governance seeks to achieve some form of public good, involves purposive acts of steering a society or polity, and serves to guide and constrain future governing behaviour (Andonova *et al.* 2009). Based on these considerations, we define governance experiments *as temporary rearrangements of the activities of a public actor or network of actors, such as the city or state, in order to advance change for the good of the public*, for example, in issues that are considered socially important yet controversial, in expensive and risky reform projects, in the piloting of grassroots initiatives, or in the critical points of complex entities (see e.g. Jowell 2003, Sabel and Zeitlin 2012). Multiple actors, influenced by vested interests, often guide governance experiments which differ from the regular renewal of governance that usually proceeds pre-decidedly and hierarchically (Sabel and Zeitlin 2012). Nevertheless, although experiments are temporary by nature, they can transform into practices and become widely deployed. This definition of governance experimentation is broader than that of policy experimentation as it encompasses, for example, local citizens' initiatives and networked projects initiated by communities.

Climate governance experiments are initiatives that address public problems relating to climate change (Hoffmann 2011). They are hard to categorise partly due to the lack of traditional political authorities, implying that actors other than governmental actors contribute to climate governance (see e.g. Dryzek 2017, Gordon and Johnson 2017). Additionally, experiments in governance are characterised by less legally binding measures than those conventionally attributed to governance. Similarly, the literature on socio-technical transition considers experiments as one way to enable and speed up the realisation of transition (e.g. Brown and Vergragt 2008, Schot and Geels 2008, Berkhout *et al.* 2010, Bos and Brown 2012). Experiments in climate action range from technical to social experiments and from product trials to systemic experiments. Attempts to bring governance and innovation perspectives closer together appear fruitful in that they account for interconnected processes and highlight agency, which is an important factor in climate change mitigation (Hildén 2014, Jordan and Huitema 2014).

The potential to attract large numbers of actors in mitigating climate change characterise climate governance experiments (Cloutier *et al.* 2015). Climate experiments can take place at local, national, regional and international levels and they tend to be limited in time and vary much in their

form, scope and scale. When compared with other kinds of climate-related experimentation, governance experimentation often has a predefined target, such as a certain reduction in carbon dioxide emissions within a given time period. Furthermore, governance experimentation and innovation may be a prerequisite for other kinds of climate innovations to be implementable in the first place (see, Brown and Vergragt 2008, Smith and Kern 2009, Evans 2011, Bos and Brown 2012). Governance experimentation is often connected to public agencies; this makes it distinct from other kinds of experiments and innovations.

The general objective of experimentation is to find new ways to do things better. In climate related experimentation, the objective is to induce change in current unsustainable practices in order to mitigate climate change. There is widespread agreement among scholars that this requires a thorough change in the current socio-technical system. Principally, the regime level represents the current production–consumption system that is unsustainable and needs to be changed and thus the dynamics of socio-technical regimes are of great interest when examining change (Moore and Hartley 2008, Smith *et al.* 2010). As governance experiments and innovations in governance dynamically renew socio-technical regimes, this also differentiates governance experimentation from other kinds of experimentation.

Innovations emerging within regimes tend to be incremental rather than radical (Geels and Kemp 2007, Geels *et al.* 2016). Therefore, regime innovations do not aim to destabilise and overthrow the current regime but enable smoother change within the regime to lessen the pressures from the landscape and niche levels, i.e. to reconfigure the socio-technical regime (Geels *et al.* 2016). As incremental innovations in stable regimes accumulate, they may provide significant performance improvements (Geels and Kemp 2007). The potentially low degree of radicalness of governance innovation corresponds to the small scale or scope of its transformative impacts. Governance innovation may still affect large geographical areas and populations, and its success is partially dependent on the participation and acceptance of those governed.

Early studies on governance experiments have examined empirical cases, and their focus has been on how these experiments and innovations relate to governance rather than to other kinds of experiments and innovations (see e.g. Hoffmann 2011, Bulkeley and Castán Broto 2013, Cloutier *et al.* 2015, Abbott 2017). Scholars have given less attention to differentiating governance innovation and experimentation from other kinds of innovation. Yet comparison of governance experiments with other kinds of experiments can reveal their intrinsic features better.

We examine the particularities of governance experiments in terms of economic, environmental, political, social and technological success factors. We understand *success factors to be prerequisites for future success of*

the experiment concerning both impacts sought for in the experiment and identified problems to be solved during implementation. These contribute to the longevity and feasibility of the experiment. Success factors then relate to the contexts of each experiment (Belassi and Tukel 1996), and we use them for comparison across kinds of experiments. This is also a limitation of the analysis as it does not provide new insights into the success factors of particular experiments (e.g. see Leidecker and Bruno 1984, Johansson 2002).

Data and methods

Database of sustainable experiments

Here, we examine how governance experiments compare with other kinds of innovations in climate action based on data from the EU-28. The EU-financed project 'CASI'[1] collected data that focuses on sustainable innovation in the areas of climate action, environment, resource efficiency and raw materials from the following sectors: agriculture, energy, finance, public administration, transport, and the water industry. The empirical data for this study are available in the project's CASIPEDIA database (www.casi2020.eu/casipedia). The CASI database aims to systematically identify and review sustainable innovations in EU countries. The cases in the database were collected through a systematic process of nomination and selection. CASI project partners and country correspondents first nominated 15–22 sustainable innovations. Then the case nominator and two academic project partners rated these nominations according to the following criteria: degree of public participation and mobilisation; sustainability and cross-sectoral linkages; multi-dimensional transformations; deployment and diffusion; and degree of novelty and originality (Popper and Velasco 2017). The database includes the six highest rated innovations from each country to ensure European coverage, and 34 additional high scoring innovations to increase representativity of each kind of innovation.

The database descriptions of innovation cases are based on publicly available data and interviews with innovators. Each description includes an identification of the kind of innovation, key areas, success factors, geographical scope, industrial sector relevance according to the ISIC[2] classification, and sustainable innovation priority area. Our focus is to examine experiments that relate to climate action, which is one of the key areas of experimentation in the database alongside resource efficiency, raw materials and environment. Many innovations fall under several key areas, so these categories overlap. Altogether, the database included 145 climate action innovations according to kind of innovation: governance (19), organisational (15), product (26), service (35), social (34), system (12) and

marketing (4). The typology follows and builds on the widely adopted *Oslo Manual* guidelines for collecting and interpreting innovation data (OECD 2005), which the Organisation for Economic Co-operation and Development has developed for innovation surveys, identifying product (including service), process, marketing and organisational innovation. The database typology is, however, more detailed than that of the *Oslo Manual* as it makes a clear distinction between product and service innovation and further distinguishes governance, social and system innovations. Process innovation, in turn, is included in product and service innovation.

The database defines governance innovation as novel forms of citizen engagement, new democratic institutions, new public and user participation in service design and delivery, and the use of public boards to govern particular choices. Organisational innovation is the implementation of a new method in business practices, workplace organisation or external relations to increase performance. Product innovation and service innovation refer respectively to the introduction of a good or service that is new or significantly improved with respect to its characteristics or intended uses. Social innovation refers to novel solutions that meet a social need, such as social housing or support for local communities, more effectively than existing solutions, leading to new or improved capabilities and relationships as well as to the better use of assets and resources. The database defines system innovation as a set of interconnected innovations (CASIPEDIA 2015). We argue that governance experiments belong to the regime level, while product experiments typically are considered in strategic niches (Hoogma *et al.* 2004). Social innovation is a niche challenger contesting the regime as it typically emerges from actors outside the established regime, who have limited capacity to induce change from within (Mulgan 2012, Repo and Matschoss 2017, Zapata Campos and Zapata 2017).

Experiments on climate action

A total of 141 experiments on climate action in the CASIPEDIA database form the empirical material of this discussion. Thus, the analysed data comprises all experiments on climate action in the database collected up to December 2015 with the exception of the four marketing innovations. Table 1 describes how these experiments relate to kinds of innovations and sustainable innovation priority areas,[3] which are topics relating to Horizon 2020's societal challenge 'Climate action, environment, resource efficiency and raw materials' (European Union 2013). The priority areas depict what sort of topics different kinds of experiments focus on in the realm of climate action.

Table 1. Percentage of climate action experiments by kind and sustainable innovation (SI) priority area.

SI priority area	Strategic intelligence and citizen participation (%)	Climate change mitigation solutions (%)	Climate action by sustainable lifestyles (%)	Eco-innovation and green economy transition (%)	Resource efficient sustainable lifestyles (%)	Eco-solutions to reduce raw material use (%)
Kind of experiment						
Governance (19)	68	53	42	32	26	–
Organisational (15)	13	60	53	40	47	20
Product (27)	–	67	41	33	33	44
Service (35)	14	43	57	37	43	20
Social (33)	27	27	88	18	70	21
System (12)	–	50	50	58	33	25

Source: compiled from CASIPEDIA 2015.

Table 1 shows that sustainable innovation experiments in climate action are distributed differently across the priority areas. Governance innovations address, in particular, strategic intelligence and citizen participation (68%) whereas social innovations mostly deal with climate action by sustainable lifestyles (88%). Although organisational, product and service innovations are spread somewhat more evenly across priority areas, differences are prevalent, giving a first indication that different kinds of innovation indeed have distinct characters. Most of the governance experiments targeting climate action are led by a governmental actor (74%). Civil society organisations manage four experiments and non-governmental organisations only one. In the database, experiments on climate action target the energy sector (29 experiments), transport (26), manufacturing (25), water (24) and agriculture (23).

Success factors of experiments on climate action

The success factors discussed here follow the conceptualisation of Johansson (2002) and Leidecker and Bruno (1984) who argue that success factors are critical issues to consider in the management of experiments. They are, accordingly, not factors that consequently lead to success of the experiment, but rather issues that are critical in its realisation. Success factors are understood to be prerequisites for future success, and the impacts they seek rely on the longevity of their success. Our research looks at *types of success factors in categories* instead of specific factors or how they have affected the outcomes of an experiment. The success factors are economic, environmental, political, social and technological. Table 2 lists examples of success factors with direct database formulations.

In the database, economic success factors relate to the efficient use of money and profits gained or savings. Economic success factors also refer to increased competitiveness and new business models and to funding in the form of investments, grants or subsidies. Environmental success factors refer to increased efficiency in resource use and to reduction in emissions and environmentally harmful activities (e.g. transport). They also relate to the support of energy change and transition towards sustainability. Political success factors are mainly associated with local political will and support, involvement of authorities (in particular local authorities) as well as securing access to, or the availability of, critical resources. Social success factors deal with social interaction and community involvement (such as co-operation with schools) and social acceptance. In particular, they include the empowerment of citizens and residents as well as social inclusion (employment of, or housing for) of families and children as well as disadvantaged people. Technological success factors are connected with new technical solutions

Table 2. Examples of success factors in CASIPEDIA.

Success factor type	Success factor	Experiment
Economic	Citizen engagement is motivated by different bonuses. Municipality clearly also saves from reduced energy bills and savings are reinvested.	Energy Efficient Municipality
	The project provides economic benefits to citizens.	Krk Island: towards Energy Independence And Zero CO_2 Emissions
Environmental	Working towards finding the most environmentally sustainable and optimal energy scenario for Estonia.	Co-Creation Practices in Enmak 2030+ Estonian Energy Sector Development Plan
	Citizens are more and more concerned about environmental and climate issues, although they often feel like lacking the knowhow to really do something. Citizens need to be 'pulled'. Ilanga therefore supports this pull-method to engage citizens in the transition towards a model in which citizens are the owner, that focuses on saving so that we have to use less resources and electricity, that is sustainable, that centres around local needs	Energybook
Political	Government brought the Eco Gozo vision on the agenda	Eco Gozo
	The idea to introduce the congestion charge was included in the electoral program of the local government. Government decided to answer to the desire of citizen who, through a specific referendum, have expressed the desire to have a more liveable city and suitable for pedestrian. Finally, the courage of the policy makers was fundamental because it is an innovation, which goes against the Italian culture of machine's use.	Area C: Congestion Charge In Milan
Social	Efficient awareness, information and market campaigns by Lund municipality to promote more sustainable modes of transportation	Lundamats – A Strategy For Sustainable Transportation System In Lund Municipality
	The strong social cohesion in the area was important for the functioning of the interest and project group	Sustainable Energy Landscape
Technological	New green technologies	Greenhouse Building Subsidies
	New technologies in the management of energy, water and recycling process.	Sharing Torino

Source: extracted from CASIPEDIA 2015.

and processes and low-energy and green technologies. These success factors relate to issues of usability and to the creation of a sufficient technological basis for the experiment. Spatial/urban and ethical success factors are also listed in the database, but infrequently, so we omitted these from the analysis.

The experiments in the database can have several success factors or only one. The factors are categorically independent of each other. For instance, the Belgian governance experiment – 'Energybook' – includes economic, environmental and social success factors. In this case, the economic success factor concerns a co-operative investment system to make school buildings more energy efficient, the environmental success factor concerns citizens using less resources and electricity, and the social success factor concerns citizen engagement through raising awareness of sustainable development around local needs. Table 2 presents some examples of the different kinds of experiments and some descriptions of their success factors.

We compare the categories of success factors of governance experiments against the success factors of the other kinds of experiments. The types of success factors are spread unevenly across all kinds of innovations. The experiments in the database range from concrete, local level experiments to national strategies. They also differ in scale, scope and topic, which is why kinds of innovations and types of success factors are analysed rather than individual cases. In the next section, we analyse differences in the types of success factors of different kinds of innovations.

Methodology

We study the relationship between kinds of innovations and the types of success factors by using contingency tables. This offers an exploratory way to provide indications of association between kinds of experiments and the types of success factors. Because we base our study on a large empirical database, our research extends beyond conventional approaches, which are more conceptual or based on a limited number of cases. The method of analysis with contingency tables provides a statistically justified way of extracting information on such a large number of cases (141) and points out differences in a statistically reliable manner.

Contingency tables are useful when examining categorical variables and can be used to assess whether their distributions differ from each other. A contingency table is a frequency distribution table showing two variables simultaneously. Contingency analysis shows whether the distribution of a variable in the data is random, or whether there are differences in the frequency distribution that cannot be explained by chance. Contingency table analysis is a useful method when the categorical variables are qualitatively different, and when the purpose is to identify differences in observed frequencies of the categories.

In this analysis, we examine how governance experiments in climate action relate to other kinds of experiments in terms of success factors. The distribution of the variables is expressed in a table so that each cell shows the observed

and expected counts. Comparing the actual count with the expected count, it is possible to determine whether the success factor is over- or under-represented in relation to other kinds of innovations and success factors.

We use Pearson's chi-squared (χ^2) test to examine how the counts in the rows are differentially distributed against the categories in the column. Accordingly, the test helps to find the relevant cells to interpret. A non-significant test result would mean that with a high probability the observed differences could be explained by chance. The test is appropriate for the data when the number of expected frequencies is 5 or more in all cells (Greenwood and Nikulin 1996, Currell 2015, Howell 2016). Castán Broto and Bulkeley (2013) have used a similar approach in the field of climate change and Repo and Matschoss (2017) in innovations in resource efficiency.

Analysis and results

The contingency table analysis of the success factors of different kinds of experiments shows that statistically significant differences are observable between kinds of experiments. Table 3 presents the kinds of experiments and the related success factor counts. The counts are accompanied by expected frequencies (in brackets). A χ^2 analysis indicates that there are statistically significant differences in how the categories of success factors relate to kinds of experiments ($\chi^2 = 35.942$, degrees of freedom (df) = 20, $p = 0.016$).

As our particular interest is in governance experimentation, we examine it more closely through pairwise analyses of success factors. This analysis provides insights into similarities and differences between experiment types in terms of their success factors. Table 4 presents the observed and expected counts (in brackets) of success factors for each kind of experiment. The success factors of governance experiments were compared pairwise against

Table 3. Contingency table for success factors.

	Type of success factors					
	Observed count (expected count)					
Kind of experiment	Economic	Environmental	Political	Social	Technological	*Sum*
Governance	13 (14)	13 (14)	14 (8)	13 (14)	7 (9)	*60*
Organisational	10 (9)	6 (8)	5 (5)	10 (9)	5 (6)	*36*
Product	20 (19)	20 (18)	6 (10)	9 (18)	22 (12)	*77*
Service	29 (27)	24 (26)	17 (15)	26 (27)	17 (18)	*113*
Social	18 (20)	21 (19)	6 (11)	31 (20)	6 (13)	*82*
System	8 (9)	10 (9)	5 (5)	8 (9)	7 (6)	*38*
Sum	*98*	*94*	*53*	*97*	*64*	***406***
Chi-squared	**35.942**					
Degrees of freedom	**20**					
***P*-value**	**0.016****					

***$p \leq 0.01$; **$p \leq 0.05$; *$p \leq 0.1$.

Table 4. Contingency table of success factors: pairwise analysis.

	Type of success factors							
	Observed count (expected count)							
Kind of experiment	Economic	Environmental	Political	Social	Technological	Chi-squared	Degrees of freedom	*P*-value
Governance	13 (14)	13 (12)	14 (12)	13 (14)	7 (8)	2.089	4	0.719
Organisational	10 (9)	6 (7)	5 (7)	10 (9)	5 (5)			
Governance	13 (14)	13 (14)	14 (9)	13 (10)	7 (13)	12.742	4	**0.013****
Product	20 (19)	20 (19)	6 (11)	9 (12)	22 (16)			
Governance	13 (15)	13 (13)	14 (11)	13 (14)	7 (8)	2.118	4	0.714
Service	29 (27)	24 (24)	17 (20)	26 (25)	17 (16)			
Governance	13 (13)	13 (14)	14 (8)	13 (19)	7 (5)	10.165	4	**0.038****
Social	18 (18)	21 (20)	6 (12)	31 (25)	6 (8)			
Governance	13 (13)	13 (14)	14 (12)	13 (13)	7 (9)	2.208	4	0.698
System	8 (8)	10 (9)	5 (7)	8 (8)	7 (5)			

***$p \leq 0.01$; **$p \leq 0.05$, *$p \leq 0.1$.

the success factors of each kind of experiment in order to examine the differences.

The analysis shows that differences are statistically significant (with 95% probability) between the distribution of success factors of governance experiments and of product experiments ($\chi^2 = 12.742$, df = 4, $p = 0.013$). That these two kinds of experiments have different success factors can be explained by the more concrete and focused nature of product experiments compared with governance experiments. Success factors of product experiments relate more to technological factors while those of governance experiments relate more to political factors. The observed count of political success factors in governance experiments is 14, whereas the statistically expected count would be 9. For product experiments, in contrast, the observed count is 6, while the statistically expected count would be 11. This means that political success factors are comparatively over-represented in the case of governance and under-represented in the case of product experiments. In contrast, the observed count for technological success factors is 7 for governance experiments (expected count 13) and for product innovations 22 (expected 16). This indicates that technological success factors have a lesser role in governance than in product experimentation.

Perhaps more interestingly, there is also a statistically significant difference between the distribution of success factors of social experiments and governance experiments ($\chi^2 = 10.165$, df = 4, $p = 0.038$). This means that what contributes to the success of governance experiments is likely to be different from what contributes to the success of social experiments. This is an interesting result as it means that, while designing the two kinds of experiments, attention should be paid to different aspects. Political aspects play a larger role in governance experimentation, whereas social aspects seem to play a smaller role. In addition, technological factors are rather absent from both governance and social experimentation. The observed count of political success factors in governance experiments is 14, whereas the statistically expected count would be 8. For social experiments, in contrast, the observed count is 6, while the statistically expected count would be 12. This means that also in this case political success factors are comparatively over-represented in the case of governance and under-represented in the case of social experiments. In contrast, the observed count for social success factors is 13 for governance experiments (expected count 19) and for social innovations 31 (expected 25). Not surprisingly, this indicates that social success factors have a lesser role in governance than in social experimentation.

According to the contingency table analysis, there are no statistically significant differences between the success factors of governance experiments and service, organisational or system experiments. This may be an indication that service, organisational and system experiments are to some extent similar to

governance experiments. No statistically significant differences among these kinds of experiments are observable in the pairwise comparisons either.

Discussion

Here, we have addressed the role of governance experiments in climate change. We have argued that governance experiments are particularly interesting from the perspective of sustainability transitions (see also, Hildén 2014, Jordan and Huitema 2014). Experiments in governance have a special role in socio-technical regimes as they may come forth within regimes and thus transform the regime from within (Bulkeley and Castán Broto 2013). Furthermore, governance experiments may provide both new modes of governance in climate action as well as promote the diffusion of the use of existing innovations targeting issues relating to climate change (e.g. Evans 2011, Cloutier *et al.* 2015).

Our research has focused on studying whether the types of success factors of governance experiments differ from those of other kinds of experiments in the climate change field. Our approach has the benefit that it is replicable by anyone using the same CASIPEDIA data, as it is publicly available. The data represents a unique set of examples of experiments from the 28 EU countries, which enables a broad perspective on governance experimentation.

We analysed success factors across kinds of experiments and innovations. The applied contingency table analysis and its accompanying Pearson's chi-squared test showed statistically significant differences between the types of success factors and certain kinds of experiments. The results show in particular that the success factors of governance experiments are different from those of product experiments. For example, the 'Eco Gozo' governance innovation case listed in Table 2 has a political success factor relating to government support for the experiment, whereas 'Quantum Storage System', a product experiment, has a technological success factor relying on technology to store and release renewable energy when needed. Governance innovation in climate change, indeed, needs to gain political support more than product innovation, which requires technological advances. This difference implies that treating innovations as products or technologies in planning and experimentation efforts does not give good guidance for managing governance experimentation, setting targets for them and evaluating them. In short, product-technological solutions are unlikely to solve climate issues related to governance and politics (see, Geels 2014).

Another important finding is that governance experiments also differ from social experiments in terms of success factors. Political success factors appear more important and social success factors less important for

governance experiments. In contrast, the social experiment 'AV Symbiosis' has a social success factor that involves the convergence of two social solutions relating to children's awareness of sustainable lifestyles. The result implies that governance experiments should be treated differently than social experiments. This is an interesting result when considering the customary distinction between technological and social innovation. While technological success factors characterise neither governance nor social experiments, these experiments still appear different and it would seem useful to formulate separate kinds of targets and processes for them. In conclusion, social experiments should not be seen as similar to governance experiments, but rather to constitute a distinct form of innovation (see also Repo and Matschoss 2017).

We did not observe statistically significant differences between the success factors of governance experiments and organisational, service and system experiments. This may be due to governance experiments having similar features to the other kinds of experiments, but the analysis cannot confirm this. Future work on the organisational, service and systemic features of governance experiments in climate action could provide interesting results.

The results contribute to the understanding of the role of experimentation in the framework of socio-technical regimes, because governance experiments arguably take place at the regime level, in particular. This is in stark contrast to product experiments and social innovations that typically emerge in niches (Hoogma *et al.* 2004) due to business opportunities or shortcomings in existing arrangements (see Mulgan 2012). Against this background, it is very interesting that the distributions of success factors for governance, product and social experiments are so different. This observation merits further attention in the conceptualisation of both governance experimentation and internal change in a regime.

Governance experiments are better positioned to facilitate change within regimes. Such change may be more incremental or even stabilising, but it may, therefore, also have the potential of greater and quicker impact as it does not challenge the regime and therefore is likely to face less resistance. In this respect, governance experiments could also facilitate the uptake of other kinds of existing and forthcoming innovations. The downside of this is that governance experiments may require more explicit acceptance from vested interests and the public, which can potentially hinder the development and adoption of innovations of a more radical kind. In conclusion, governance experiments that address climate change should give priority to political factors.

Conclusions

Experiments provide opportunities to identify novel ways to address climate change and provide improved possibilities for transition to low-

carbon societies. Usually, including in the realm of climate change, research seeks such novelty from the outskirts of existing socio-technical regimes (Geels 2002, Upham *et al.* 2014). Scholars of sustainability transitions expect niche innovations, in particular, to provide change in slowly evolving regimes (Geels 2002) that are stable and reluctant to change (Scrase and Smith 2009). Yet this may be only half the story as regimes can also change from within forced by external pressures from the macro level as well as in response to challengers from the niches. Transition scholars often consider regime-internal change processes to be incremental (Geels and Kemp 2007), but its particularity is that it has the potential for major impact – and socio-technical regimes may indeed provide both regeneration and balance for transition to low-carbon societies.

In this transition it is the combination of inducing change from within the regime as well as distinct success factors that make governance experiments particularly interesting. Rather than representing top-down policy implementation, governance experiments provide opportunities to overcome policy stalemates and institutional resistance to change as experiments are allowed to fail, because even then they provide valuable insights.

Our work, based on an analysis of regime and multiple niche innovations, has been exploratory, attempting to identify how governance innovation differs from other kinds of innovations in terms of future success. As suggested by Geels *et al.* (2016), it had an empirical focus and examined a large number and variety of cases. Analytical and heuristic transition models such as the MLP may become powerful policy tools when backed up by solid empirical data.

Notes

1. CASI = Public Participation in Developing a Common Framework for Assessment and Management of Sustainable Innovation.
2. The International Standard Industrial Classification of All Economic Activities is a United Nations industry classification system.
3. The developers of the CASIPEDIA database compiled sustainable innovation priority areas from the European Council decision, chapter five, establishing the programme implementation of Horizon 2020 (European Union 2013, Popper and Velasco 2017). We list them here as they are presented in the database.

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